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# MULTIMEDIA UNIVERSITY

## FINAL EXAMINATION

TRIMESTER 1, 2018/2019

**EMF3046 – RF MEASUREMENT TECHNIQUES**  
(TE)

18 OCTOBER 2018  
2.30 P.M - 4.30 P.M.  
(2 Hours)

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### INSTRUCTION TO STUDENT

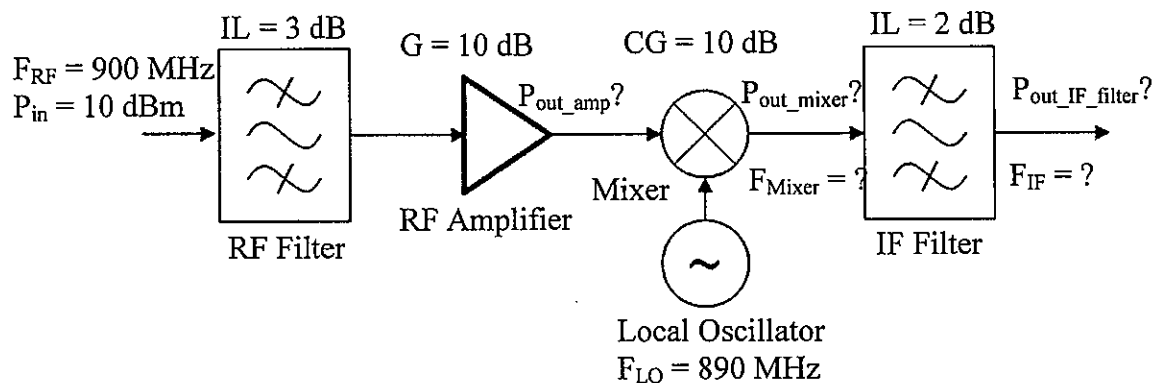
1. This Question paper consists of 6 pages with 4 Questions only.
2. Answer all **FOUR (4)** questions. All questions carry equal marks and the distribution of the marks for each question is given.
3. Please print all your answers in the Answer Booklet provided.

**Question 1**

- a) List TWO (2) advantages of using decibel (dB) scale in RF/Microwave power measurements.

[8 Marks]

- b) An RF signal with input power ( $P_{in}$ ) of 10 dBm and frequency ( $F_{RF}$ ) of 900 MHz is connected to a receiver front-end shown in Figure Q1, with the given insertion loss (IL) of the filters, gain (G) of the amplifier and conversion gain (CG) of the mixer.

**Figure Q1**

- Briefly explain the usages of RF and IF filters used in this receiver. [4 Marks]
- Determine the overall gain of this receiver (in both normal and dB scale) and its respective image frequency. [4 Marks]
- Determine the RF power that will be measured at the RF amplifier output ( $P_{out\_amp}$ , in mW). [2 Marks]
- List all the possible frequencies appeared after the mixer. Next, determine the down-converted IF frequency,  $F_{IF}$ . [3 Marks]
- Determine the IF power that will be measured at the mixer output ( $P_{out\_mixer}$ , in mW). [2 Marks]
- Determine the IF power that will be measured at IF filter output ( $P_{out\_IF\_filter}$ , in mW). [2 Marks]

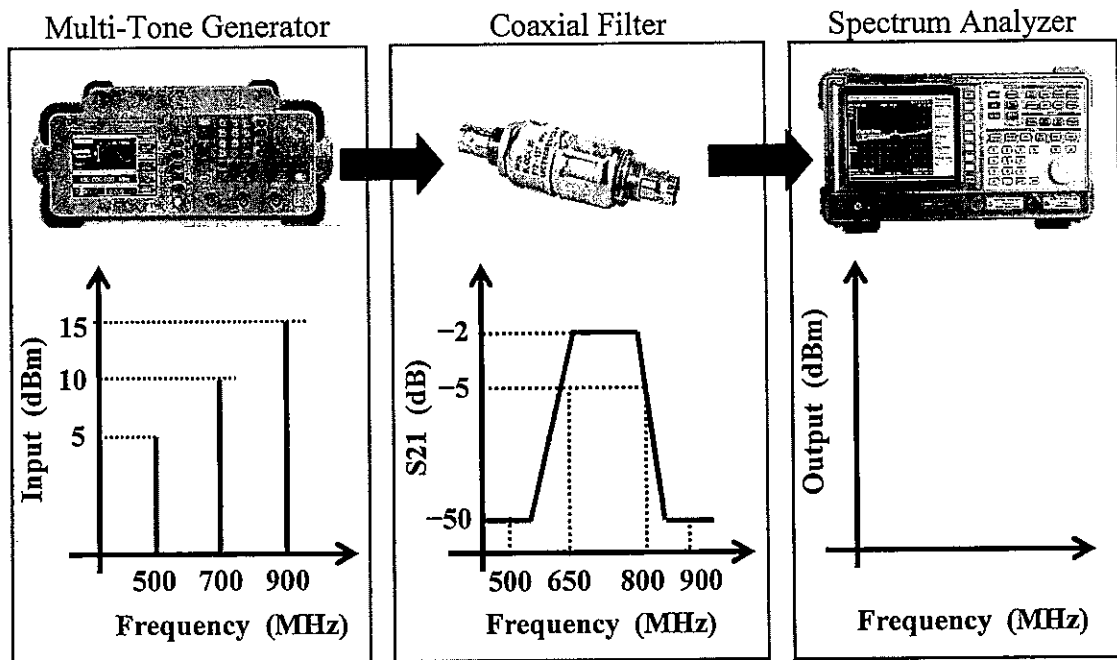
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**Question 2**

- a) Explain the principle of operation for a swept-tuned spectrum analyzer using a block diagram. [9 Marks]

- b) A coaxial filter is connected in between the multi-tone signal generator and spectrum analyzer as shown below in Figure Q2.

(Assume that the connecting cables and connectors have no loss)



**Figure Q2**

- What type of filter is shown in the above measurement? [1 Mark]
- Briefly explain TWO (2) functions of filter used in RF applications. [4 Marks]
- Determine the insertion loss, cut-off frequencies, center frequency and 3 dB bandwidth of the filter. [4 Marks]
- What are the stop-band frequencies and rejections of the filter? [4 Marks]
- Sketch the output of the spectrum analyzer in the graph above, indicating the frequency points and power level. [3 Marks]

**Continued...**

**Question 3**

- a) Explain briefly THREE (3) errors occurred in a typical vector network analyzer measurement. [6 Marks]
- b) A device under test (DUT) has the following  $S$ -parameters (in touchstone or S2P file format) before and after the 2-port Short-Open-Load-Thru (SOLT) calibration, as shown in Figure Q3.

! Un-calibrated									
! S11 S21 S12 S22									
# GHZ S MA R 50									
.100	1.000	-10.5	9.271	172.8	.014	83.1	.830	-6.9	
.200	.983	-20.2	9.176	165.5	.027	76.6	.825	-13.8	
.300	.977	-31.4	8.885	158.5	.040	70.7	.803	-20.1	
.400	.964	-41.1	8.652	151.9	.051	65.1	.784	-26.3	
.500	.928	-50.4	8.301	144.4	.061	58.6	.745	-32.7	
.600	.907	-59.3	7.956	138.5	.071	53.8	.722	-37.9	
.700	.885	-67.6	7.607	132.8	.078	49.2	.691	-43.2	
.800	.864	-75.3	7.262	127.6	.085	44.9	.665	-47.9	
.900	.847	-82.6	6.904	122.6	.091	41.0	.641	-51.8	
1.000	.828	-89.2	6.591	117.9	.096	37.5	.614	-55.8	

! SOLT calibrated									
! S11 S21 S12 S22									
# GHZ S MA R 50									
.100	.100	-80.5	12.27	122.8	.004	83.1	.130	-6.9	
.200	.183	-90.2	12.17	125.5	.017	76.6	.125	-3.8	
.300	.177	-91.4	11.85	138.5	.020	70.7	.103	-5.1	
.400	.164	-91.1	11.62	161.9	.011	65.1	.084	6.3	
.500	.128	-90.4	11.30	184.4	.031	58.6	.045	2.7	
.600	.090	-99.3	10.56	118.5	.011	53.8	.022	3.9	
.700	.085	67.6	10.67	152.8	.018	49.2	.091	4.2	
.800	.064	25.3	10.62	117.6	.025	44.9	.065	4.9	
.900	.047	2.6	10.04	112.6	.011	41.0	.041	5.8	
1.000	.028	0.0	10.91	107.9	.016	37.5	.014	0.0	

**Figure Q3**

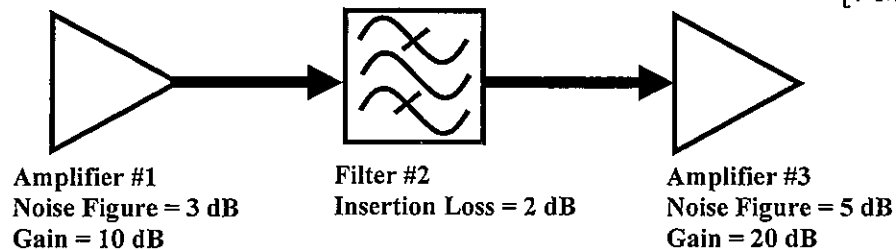
- i) Explain briefly TWO (2) advantages of 2-port SOLT calibration. [4 Marks]
- ii) List THREE (3) errors removed by 2-port SOLT calibration. [3 Marks]
- iii) Determine the frequency range and reference impedance used in the above measurements. [2 Marks]
- iv) Determine the input impedance ( $Z_{in}$ ) and output impedance ( $Z_{out}$ ) of the DUT before and after performing the calibration at 1 GHz. [2 Marks]
- v) Are the input and output of the DUT matched to reference impedance, after performing the 2-port SOLT calibration at 1 GHz? Justify your answer. [2 Marks]
- vi) Determine the input and output return losses of the DUT before and after performing the calibrations at 1 GHz. [2 Marks]
- vii) Is the above DUT has power gain or power loss at 1 GHz? Justify your answer. [2 Marks]
- viii) What is the power gain or power loss of the above DUT in dB at 1 GHz? [1 Mark]
- ix) What is the isolation the above DUT in dB at 1 GHz? [1 Mark]

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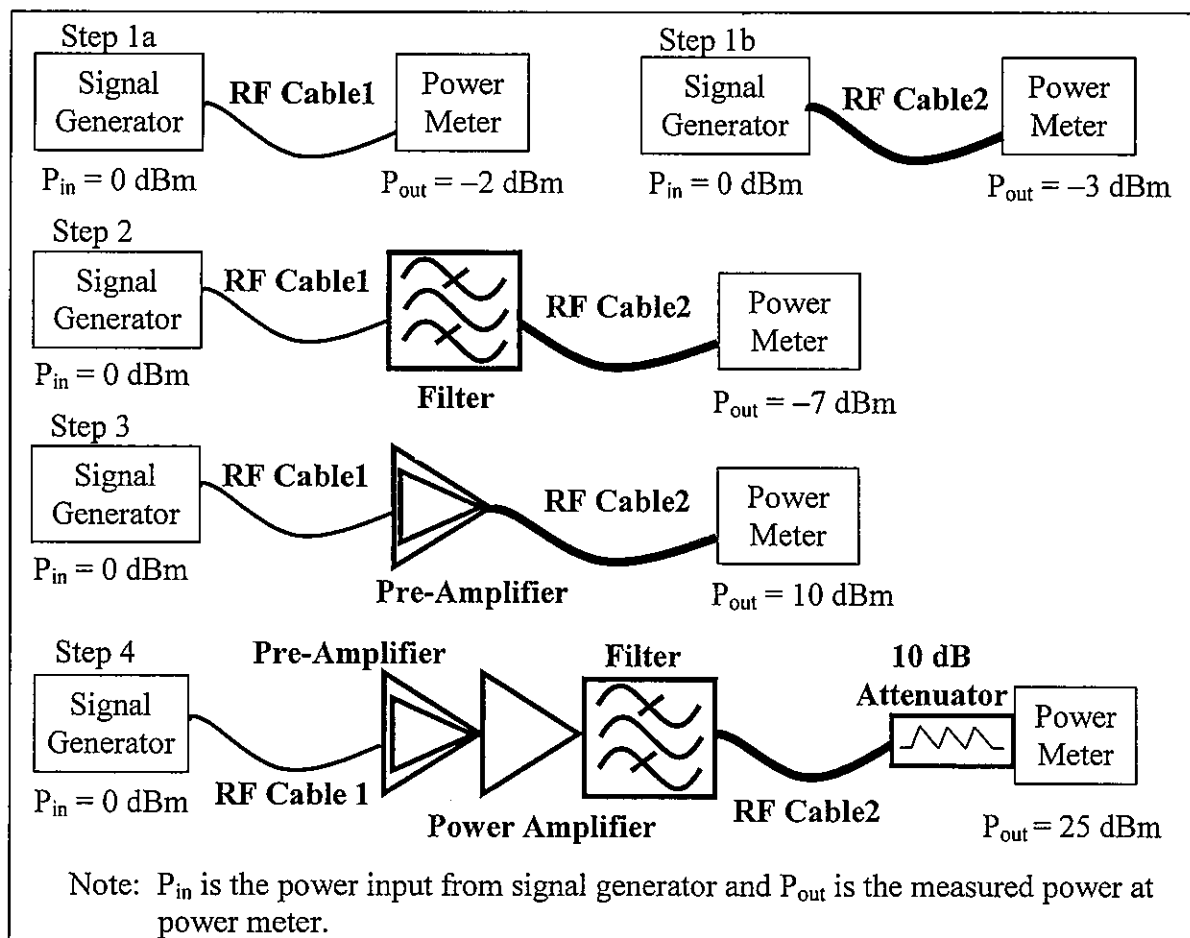
**Question 4**

- a) A low noise amplifier with noise figure of 3 dB and power gain of 10 dB is connected to the input of a filter with insertion loss of 2 dB and then followed by an amplifier with noise figure of 5 dB and power gain of 20 dB (as shown in Figure Q4a). Determine the total power gain (in absolute unit and decibel, dB), noise factor and noise figure contributed by this system.

[7 Marks]

**Figure Q4a**

- b) The procedures of measuring gain for a power amplifier with filter, pre-amplifier and radio frequency (RF) cables are illustrated below (Figure Q4b) :

**Figure Q4b**

Continued...

- i) Explain briefly THREE (3) characteristics of an RF Power amplifier [6 Marks]
- ii) Explain briefly the function of filter in the above measurement. [2 Marks]
- iii) Explain briefly the function of pre-amplifier in the above measurement. [2 Marks]
- iv) Explain briefly the function of attenuator in the above measurement. [2 Marks]
- v) What are the power losses contributed by the RF Cable1 and RF Cable2? [2 Marks]
- vi) Determine the insertion loss of the filter. [2 Marks]
- vii) Determine the gain of the power-amplifier. [2 Marks]

**End of Page**

